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PTO/SB/05 (4/98)

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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No. 2447-012

First Inventor or Application Identifier COHEN, Lawrence T.

Title Electrode Array with Non-Uniform Electrode Spacing

Express Mail Label No. FI 170399260US

jc857 U.S.P.T.O.
09/6/2000

08/28/00

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. * Fee Transmittal Form (e.g., PTO/SB/17)
(Submit an original and a duplicate for fee processing)
2. Specification [Total Pages 7]
 - Descriptive title of the Invention
 - Cross References to Related Applications
 - Statement Regarding Fed sponsored R & D
 - Reference to Microfiche Appendix
 - Background of the Invention
 - Brief Summary of the Invention
 - Brief Description of the Drawings (if filed)
 - Detailed Description
 - Claim(s)
 - Abstract of the Disclosure
3. Drawing(s) (35 U.S.C. 113) [Total Sheets 2]
4. Oath or Declaration [Total Pages]
- a. Newly executed (original or copy)
- b. Copy from a prior application (37 C.F.R. § 1.63(d))
(for continuation/divisional with Box 16 completed)
 - i. DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

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ADDRESS TO: Assistant Commissioner for Patents
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5. Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
 - a. Computer Readable Copy
 - b. Paper Copy (identical to computer copy)
 - c. Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. Assignment Papers (cover sheet & document(s))
8. 37 C.F.R. § 3.73(b) Statement Power of (when there is an assignee) Attorney
9. English Translation Document (if applicable)
10. Information Disclosure Statement (IDS)/PTO-1449 Copies of IDS Citations
11. Preliminary Amendment
12. Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)
 - * Small Entity Statement filed in prior application, Statement(s) Status still proper and desired (PTO/SB/09-12)
 - 13. Certified Copy of Priority Document(s)
(if foreign priority is claimed)
 - 14. Other: Return Receipt Postcard

16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:

 Continuation Divisional Continuation-in-part (CIP)

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Prior application information: Examiner _____

Group / Art Unit: _____

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS Customer Number or Bar Code Labelor Correspondence address below

Name

PATENT TRADEMARK OFFICE

Address

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Fax

Name (Print/Type) Tiberiu WEISZ

Registration No. (Attorney/Agent)

29,876

Signature

Date August 28, 2000

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for FY 2000

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TOTAL AMOUNT OF PAYMENT (\$ 345)

Complete if Known

Application Number	To Be Assigned
Filing Date	Herewith
First Named Inventor	COHEN, Lawrence T.
Examiner Name	To Be Assigned
Group / Art Unit	To Be Assigned
Attorney Docket No.	2447-012

METHOD OF PAYMENT (check one)

1. The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:

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Deposit Account Name Gottlieb Rackman & Reisman, P.C.

 Charge Any Additional Fee Required Under 37 CFR §§ 1.16 and 1.172. Payment Enclosed: Check Money Order Other**FEE CALCULATION****1. BASIC FILING FEE**

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
101 690	201 345	Utility filing fee	345
106 310	206 155	Design filing fee	
107 480	207 240	Plant filing fee	
108 690	208 345	Reissue filing fee	
114 150	214 75	Provisional filing fee	

SUBTOTAL (1) (\$ 345)

2. EXTRA CLAIM FEES

	Extra Claims	Fee from below	Fee Paid
Total Claims	13	-20** = 0	X = _____
Independent Claims	2	- 3** = 0	X = _____
Multiple Dependent			= _____

**or number previously paid, if greater; For Reissues, see below

Large Entity Small Entity

Fee Code (\$)	Fee Code (\$)	Fee Description
103 18	203 9	Claims in excess of 20
102 78	202 39	Independent claims in excess of 3
104 260	204 130	Multiple dependent claim, if not paid
109 78	209 39	** Reissue independent claims over original patent
110 18	210 9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) (\$)

3. ADDITIONAL FEES

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
105 130	205 65	Surcharge - late filing fee or oath	
127 50	227 25	Surcharge - late provisional filing fee or cover sheet	
139 130	139 130	Non-English specification	
147 2,520	147 2,520	For filing a request for reexamination	
112 920*	112 920*	Requesting publication of SIR prior to Examiner action	
113 1,840*	113 1,840*	Requesting publication of SIR after Examiner action	
115 110	215 55	Extension for reply within first month	
116 380	216 190	Extension for reply within second month	
117 870	217 435	Extension for reply within third month	
118 1,360	218 680	Extension for reply within fourth month	
128 1,850	228 925	Extension for reply within fifth month	
119 300	219 150	Notice of Appeal	
120 300	220 150	Filing a brief in support of an appeal	
121 260	221 130	Request for oral hearing	
138 1,510	138 1,510	Petition to institute a public use proceeding	
140 110	240 55	Petition to revive - unavoidable	
141 1,210	241 605	Petition to revive - unintentional	
142 1,210	242 605	Utility issue fee (or reissue)	
143 430	243 215	Design issue fee	
144 580	244 290	Plant issue fee	
122 130	122 130	Petitions to the Commissioner	
123 50	123 50	Petitions related to provisional applications	
126 240	126 240	Submission of Information Disclosure Stmt	
581 40	581 40	Recording each patent assignment per property (times number of properties)	
146 690	246 345	Filing a submission after final rejection (37 CFR § 1.129(a))	
149 690	249 345	For each additional invention to be examined (37 CFR § 1.129(b))	

Other fee (specify) _____

Other fee (specify) _____

SUBTOTAL (3) (\$)

* Reduced by Basic Filing Fee Paid

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Signature 

Registration No. (Attorney/Agent) 29,876

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Date August 28, 2000

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Inventor(s):

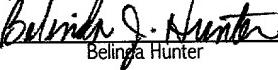
COHEN, Lawrence T.

**ELECTRODE ARRAY WITH NON-UNIFORM
ELECTRODE SPACING**

CERTIFICATE OF EXPRESS MAIL UNDER 37 CFR §1.10

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ELECTRODE ARRAY WITH NON-UNIFORM ELECTRODE SPACING

Technical Field

This invention relates to electrode arrays for intra-cochlear implantation.

Background Art

5 Intracochlear electrode arrays have been successfully utilised for many years as a stimulation mechanism for auditory prostheses. The function of the array is to provide electrical stimuli, by selecting one or more electrodes in the array and delivering a stimulus pulse to the electrodes, so as to produce an auditory percept in a patient.

10 The array is connected to a receiver-stimulator unit, which in turn typically communicates transcutaneously with an externally worn speech processor and sound transducer.

15 Over time, many different strategies have been applied both to analyse the speech and sound signals received by the transducer, and to provide appropriate stimuli to selected electrodes in the array so as to optimise the speech and sound perception of the patient.

All commercially available cochlear implants utilise electrode arrays in which the electrodes are substantially equally spaced along the length of the array.

20 Recently, due to an increased understanding of the physiology of the cochlear, a number of proposals have been made to provide an electrode array which is shaped so as to be located near the inner wall of the scala tympani. By position the array in such a location the electrical stimulation delivered by the electrodes to a particular site on the cochlea is more localised
25 resulting in an improved system providing greater auditory perception to the patient.

It is an object of the present invention to provide an electrode array which improves the fidelity of the reproduction of the audio spectrum in the percept of the cochlear implant recipient, for a given number of electrodes.

30 Summary of the Invention

DOCUMENT NUMBER: 00000000000000000000000000000000

Broadly, the present invention provides an electrode array in which the electrodes are not evenly spaced, but rather are differentially spaced in order to better target selected regions of the cochlea.

- According to one aspect, the present invention provides an
- 5 intracochlear electrode array in which the electrodes are closer together at the apical end of the array. This may be achieved in various ways – for example, by a uniformly graduated change in spacing, or by selecting two or more regions of the electrode array to have different spacings.

This aspect of the invention is based on several factors. It has been

10 determined that it is desirable for the spacing of electrodes to correspond to uniform intervals along the organ of Corti. While audio stimulation receptors on the outer wall of the scala tympani are generally regularly spaced, receptors on the inner wall tend to be spaced closer together the further one travels inwardly. It has been determined that receptors on the inner wall of the

15 scala tympani are more sensitive than those on the outer wall, and it would therefore be more effective to stimulate these inner receptors rather than the outer ones as is traditionally done. Preferably, the electrode spacing should be determined by the intercepts, along the intended array placement, of lines passing from a modiolar centre point through points spaced at equal

20 increments along the organ of Corti. This arrangement generally maximises the uniformity of spectral coverage for a given number of electrodes, and accordingly the probability of good speech perception by an implant recipient.

According to another aspect, the present invention provides an electrode array with the spacing of electrodes varied so as to provide a higher

25 density of electrodes at specific regions – for example, along a part of the array intended to stimulate one or more regions of the neural structures corresponding to frequency bands which are considered particularly important for speech recognition. This could be based on many different considerations – the essence of this aspect of the invention is simply to provide electrodes at

30 reduced spacing in areas of particular interest.

Brief Description of the Drawings

The invention will now be described with reference to the accompanying figures, in which:

- Figure 1 is a schematic illustration of a conventional electrode array in a
5 scala tympani; and
- Figure 2 is a schematic illustration of an electrode array with non-uniform
spacing of electrodes.

Referring to figure 1, this is based upon an X-Ray of an implanted device having a curved configuration, for example an array according to
10 PCT/AU99/00391 by Cochlear Limited. It will be appreciated that this is a sectional view showing the scala tympani 10, which in fact curves into the page, but for present purposes the invention can be explained with reference to a two dimensioned projection.

Dotted line 15 represents the organ of Corti, on which the audio
15 receptors 12 are disposed at the intersection of radial lines 11 (only one thus labeled) and the organ of Corti 15. Radial lines 11 are shown extending from the modiolar centre 16, and are of course, purely represented for the purpose of illustrating the present inventive concept. Receptors 12 are composed of neural structures, including spiral ganglion cells, which extend radially inward
20 from the organ of Corti 15. It is in fact these cells which are stimulated by the stimuli produced by electrodes in a cochlear implant.

It will be noted that receptors 12 are disposed at equal intervals along the organ of Corti 15 (at critical bands), even as the curvature increases as the cochlea spirals inwards. The most effective stimulation of these receptors is
25 achieved by direct stimulation by electrodes, and so cochlear implants have been traditionally constructed with electrodes spaced equally to correspond with the spacing of these critical bands. These electrodes are shown as elements 13 on cochlear implant 14.

It has been determined that receptors are more sensitive on the inner
30 wall 18 of the scala timpani 10. Accordingly, it has been found that a better result is achieved by a cochlear implant having electrodes stimulating receptors on the inner wall. To achieve this, the electrodes are caused to lie

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against the inner wall 18, to make contact with receptors 17 (lying on the intersection of radial lines 11 and the inner wall 18 of scala tympani 10).

As can be seen in figure 2, the receptors 17 on the inner wall 18, are spaced more and more closely together, as they approach the centre of the spiral of the cochlea. Thus, to maintain effective stimulation contact with receptors 17, electrodes 13 of the electrode array 14 are spaced with decreasing separation to each other the closer they approach the apical end of the electrode array 14.

Therefore, with an understanding of the physiology and geometry of the cochlea together with an understanding of the tonotopical nature of the cochlea, an electrode array can be designed to improve the fidelity of the reproduction of the audio spectrum in the percept of the cochlear implant recipient. This can be done by arranging the placement of the electrodes along the electrode array such that the spectral coverage of the electrodes are maximised to ensure optimum stimulation of the cochlea is achieved.

It will be appreciated that in the application of the present invention, the excitation by the electrodes is assumed to be substantially radial.

It may also be desired to take into account two further effects. The structures are considerably more complex than is apparent from the schematics. At the basal end of the scala tympani, the organ of Corti lies closer to the inner wall 18 and the spacing of the most basal electrodes could be reduced to take account of this. At the apical end, there is a greater angular offset between the organ of corti 15 and the underlying cell bodies, and again the spacing could be adjusted to account for this effect.

It will be appreciated by those skilled in the art that the present invention can be readily manufactured by existing techniques, and could be of any desired electrode geometry or cross-sectional shape. The present invention is concerned with the spacing of the electrodes, not their construction.

CLAIMS:

1. An electrode array for use in a cochlear implant, said electrode array having electrodes selectively positioned along said electrode array in order to better target selected regions of the cochlea.
2. An electrode array according to claim 1 wherein the spacing between adjacent electrodes is less at an apical end of the electrode array than at a basal end.
3. An electrode array according to claim 1 or 2, wherein one region of the electrode array has electrodes which are spaced from each other differently to electrodes from at least one other region of said electrode array.
4. An electrode array according to claim 1 or 2 wherein the spacing between consecutive electrodes is uniformly graduated.
5. An electrode array according to claim 3 or 4 wherein said spacing between adjacent electrodes is such as to correspond closely with the spacing of auditory receptors on the inner wall of the scala tympani.
6. A method of constructing a cochlear electrode array for implantation into a cochlea of the patient as part of a cochlear implant system, the method including:
 - determining the regions of the cochlea where stimulation is desired; and
 - positioning the electrodes along the electrode array in a location or locations that will enable stimulation of the desired site of the cochlea when the electrode array has been inserted.

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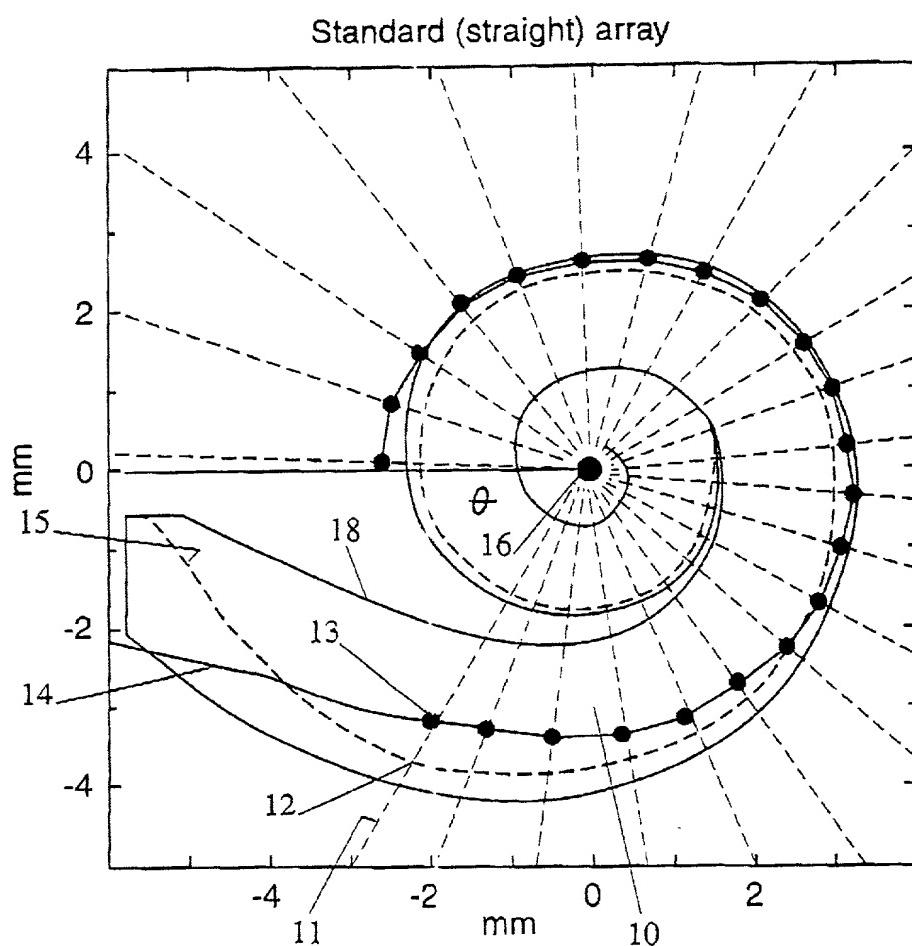
7. A method according to claim 6 wherein the step of positioning the electrodes includes positioning the electrodes such that the spacing between adjacent electrodes is less at the apical end of the electrode array than at the basilar end.
8. A method according to claim 6 wherein the step of positioning the electrodes including positioning the electrodes such that the spacing between adjacent electrodes differs in differing regions along the electrode array.
9. A method according to claim 6 or 7 wherein the step of positioning the electrodes including positioning the electrodes such that the spacing between consecutive electrodes is uniformly graduated.

ABSTRACT

An electrode array for use with a cochlear implant is disclosed, which has electrodes selectively spaced to better target selected regions of the cochlea. In one form, the spacing between adjacent electrodes decreases 5 towards an apical end of the array allowing the electrodes to better target receptors on the inner wall of the scala tympani of the cochlea.

1/2

Fig 1.



2/2

Fig 2.

